A biomimetic extraction for measuring the bioaccessibility of PAH to benthic invertebrates

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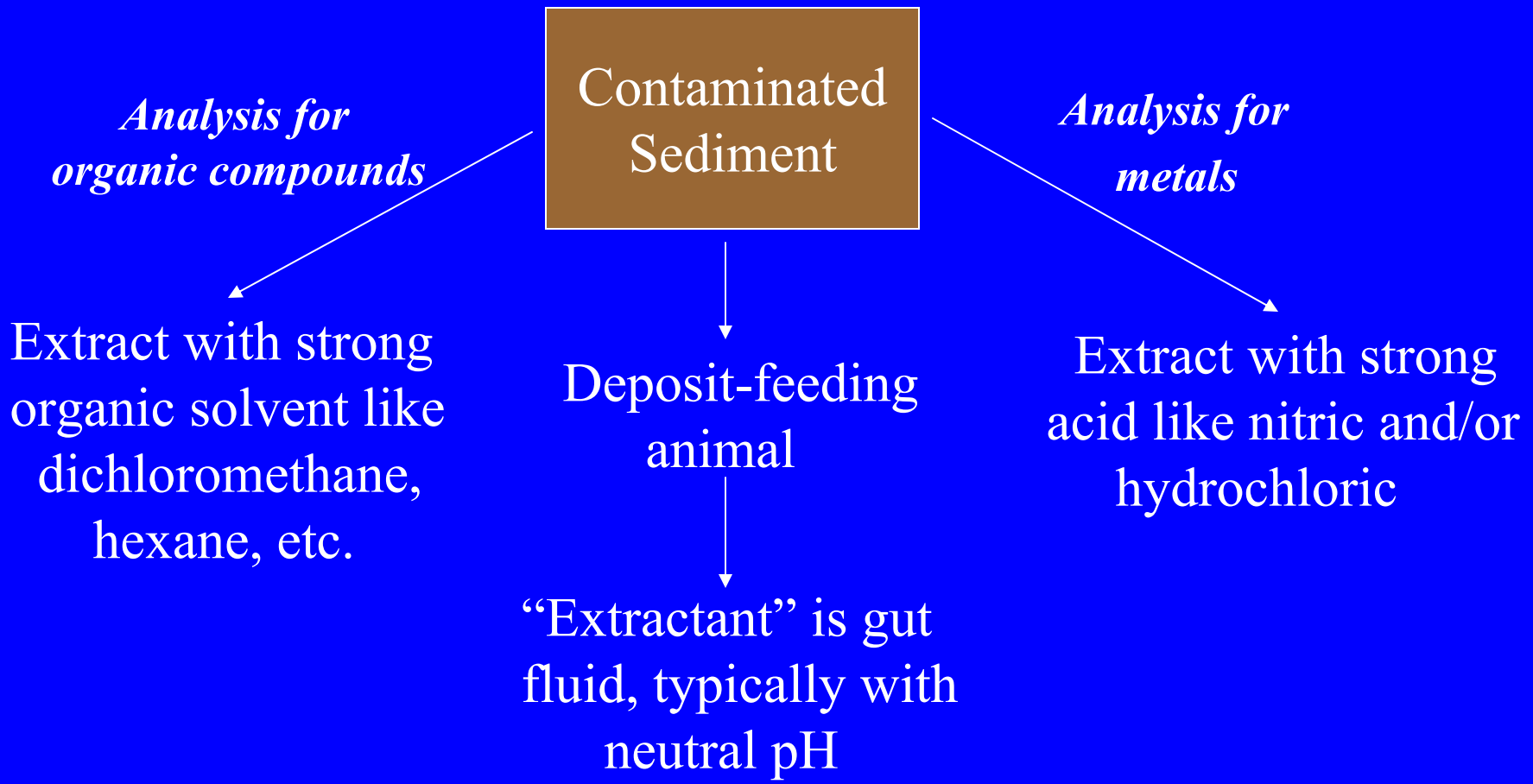
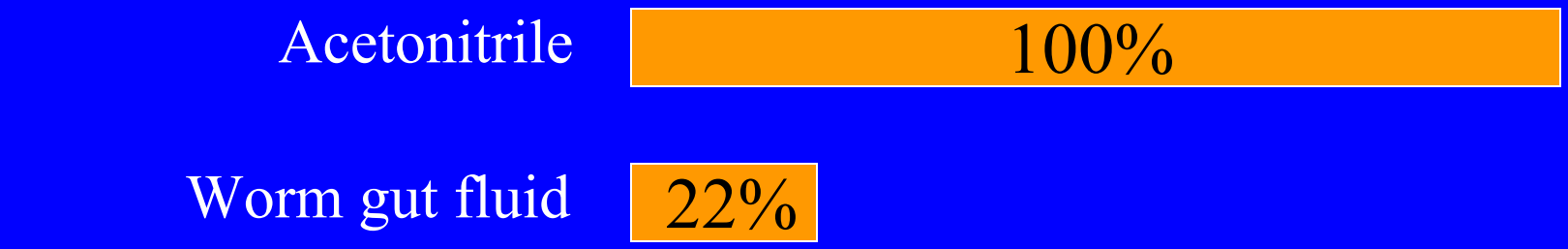
Sediment Extraction Methods

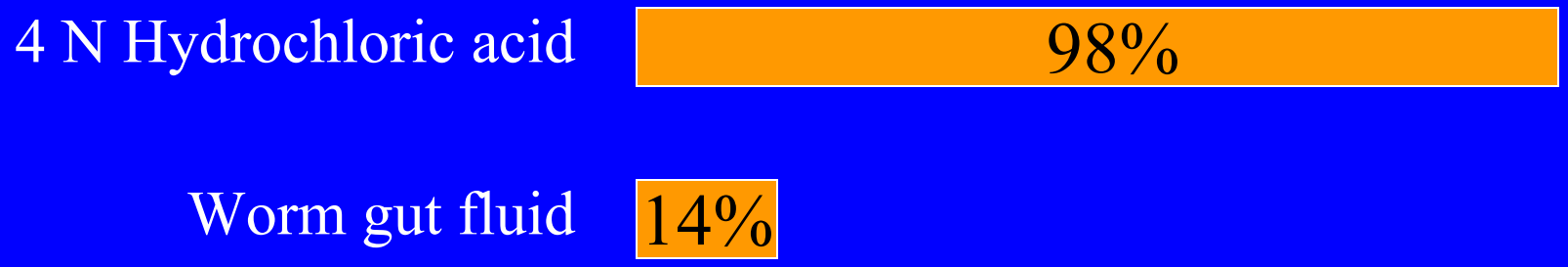


Comparative Extraction Efficiency

Extraction of benzo(a)pyrene from sediment



Extraction of zinc from sediment



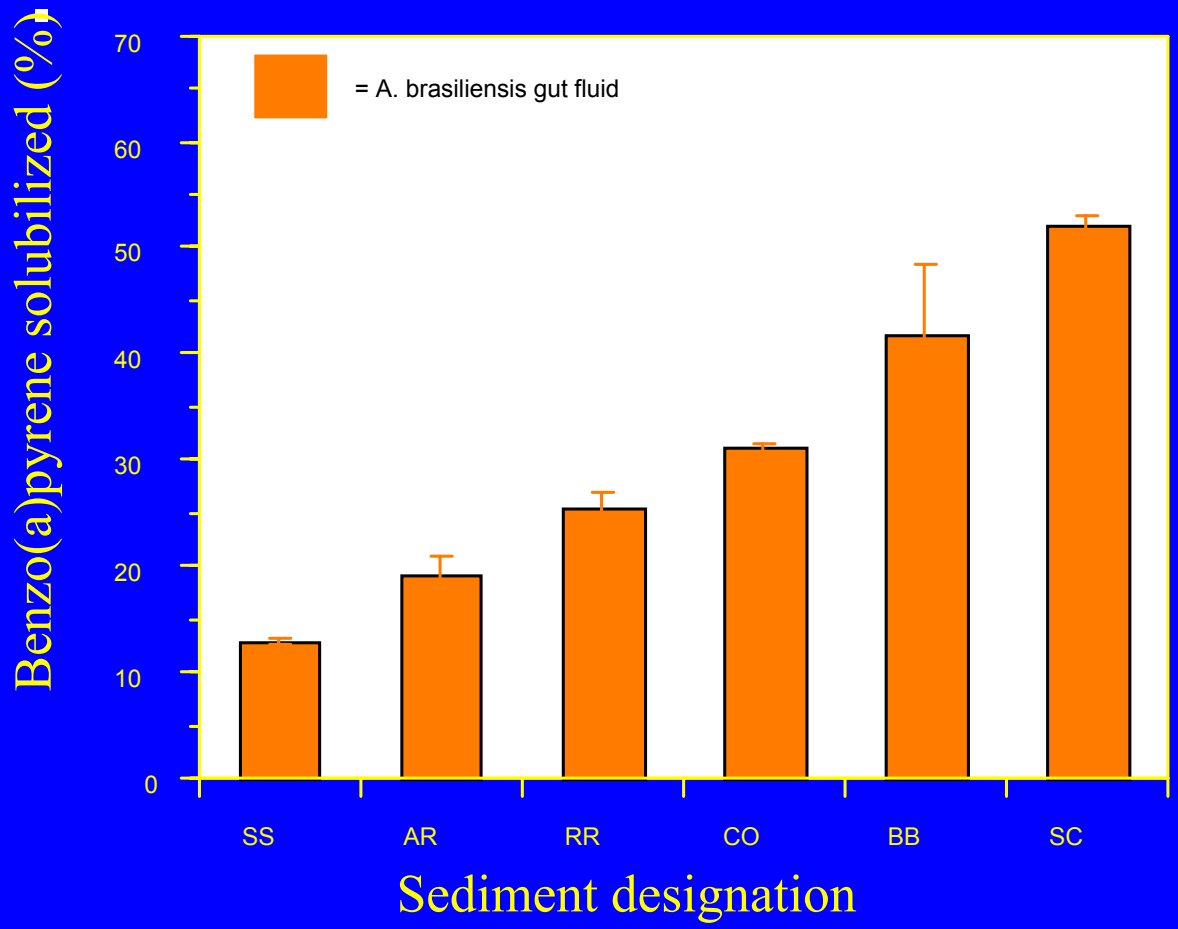
Arenicola brasiliensis

Gut of A. brasiliensis

Procedure for digestive fluid extraction of sediments

1. Obtain gut fluid from midgut of large deposit feeder.
2. Composite fluid from multiple individuals.
3. Store fluid at -90 C
4. Mix 0.5 g sediment with 0.8 ml fluid.
5. Continuous agitation for 1-2 hr.
6. Centrifuge to recover supernatant.
7. Amount of contaminant solubilized is considered to represent the fraction bioaccessible to the organism through the digestive route.

Comparative bioaccessibility among sediments



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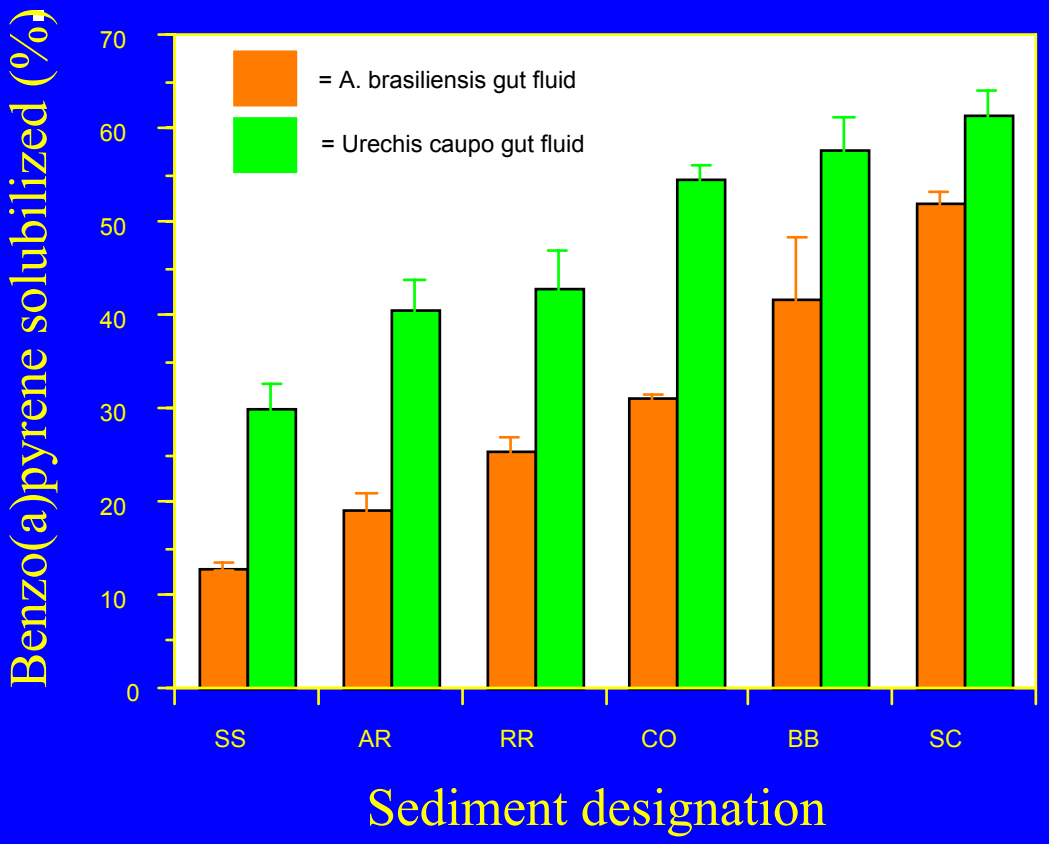


How representative is Arenicola gut fluid of other invertebrates?

Is the approach useful to predict in vivo bioaccessibility or bioavailability?

If digestive fluid extraction is to be used to assess bioaccessibility of contaminants from sediments….

What is the mechanism for enhanced solubilization in gut fluid?

Is there an alternative to real gut fluid?

Species from which gut fluid was obtained

Annelida

- Abarenicola pacifica
- Abarenicola vagabunda
- Arenicola brasiliensis
- Arenicola marina
- Nephtys discors
- Travisia foetida

Mollusca

- Archidoris montereyensis
- Katharina tunicata

Anthozoa

- Urticina crassicornis

Echinodermata

- Brisaster latifrons
- Chirdota sp.
- Eupentacta quinquesimata
- Molpadia intermedia
- Parastichopus californicus

Echiura

- Echiurus echiurus
- Urechis caupo

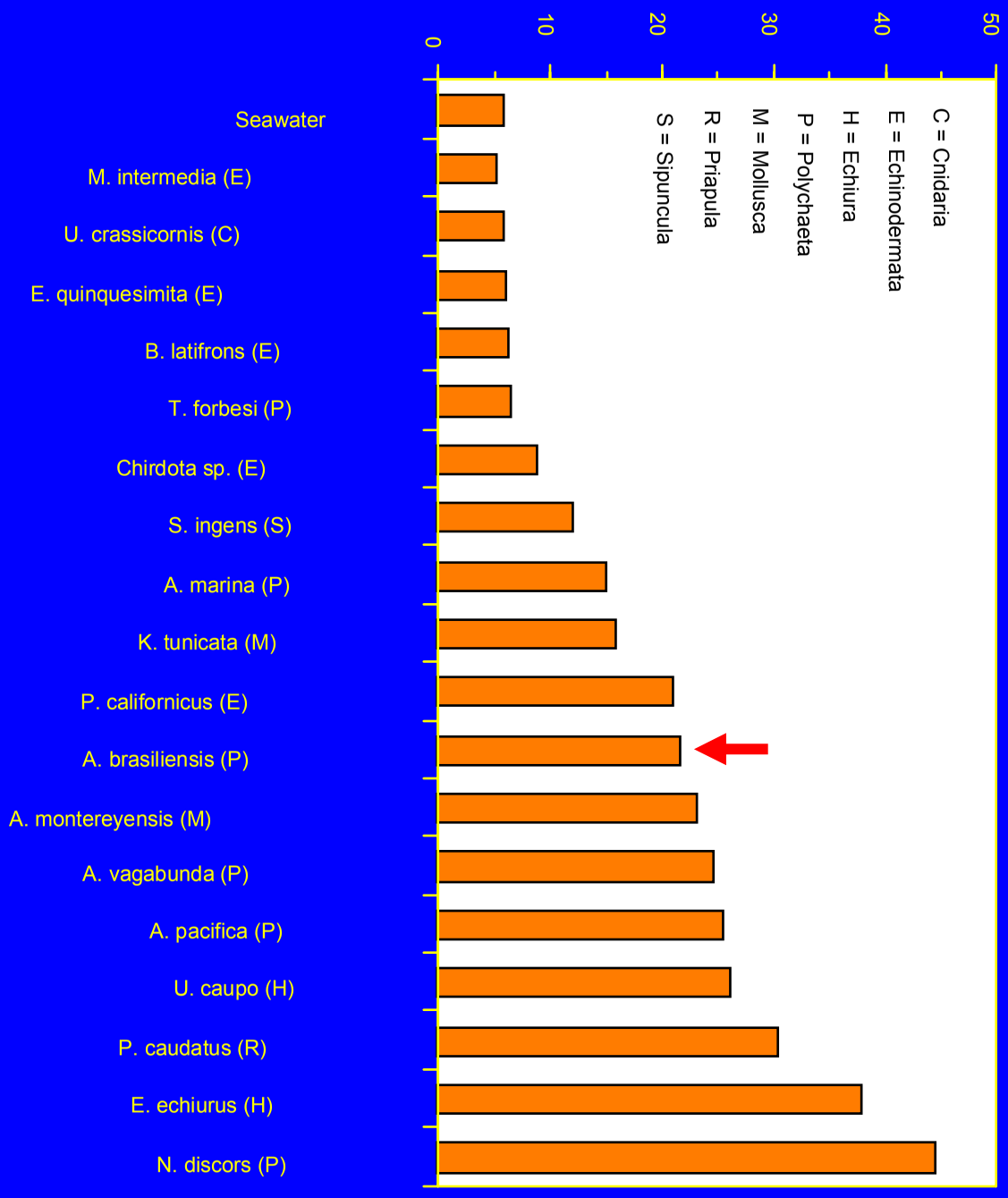
Sipuncula

- Siphonosoma ingens

Priapula

- Priapulus caudatus

Benzo(a)pyrene extracted (%)



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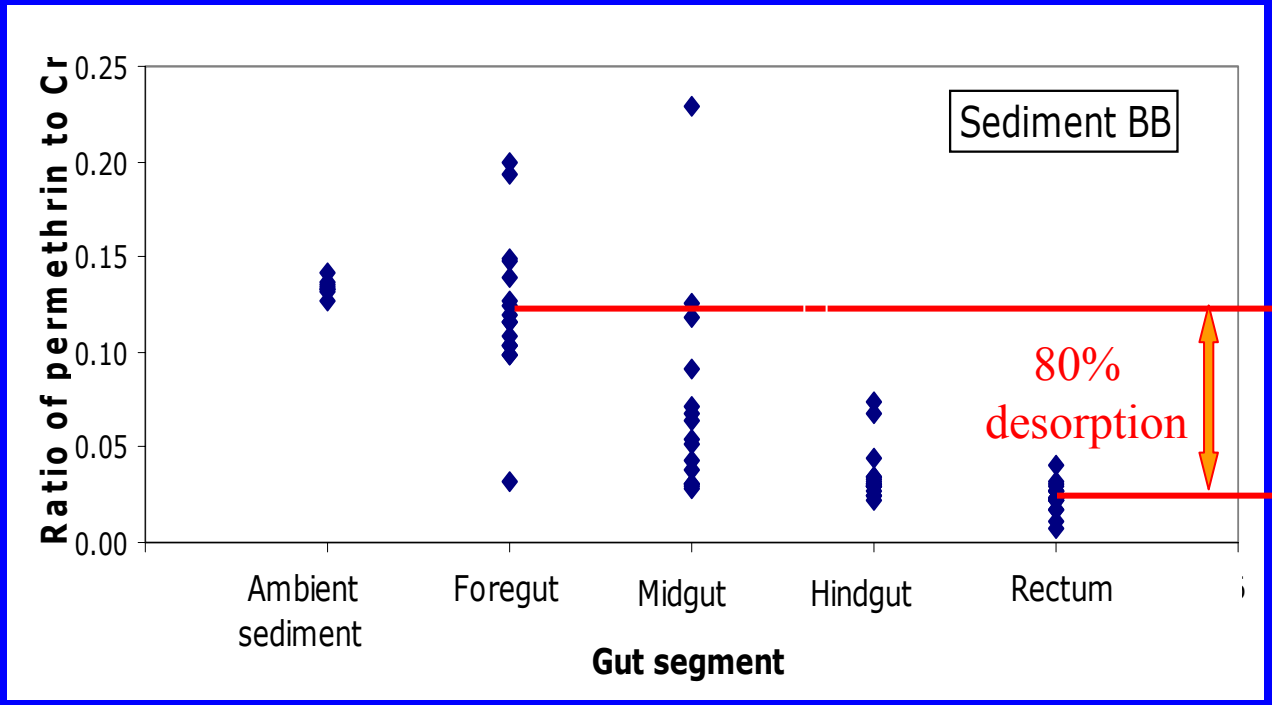
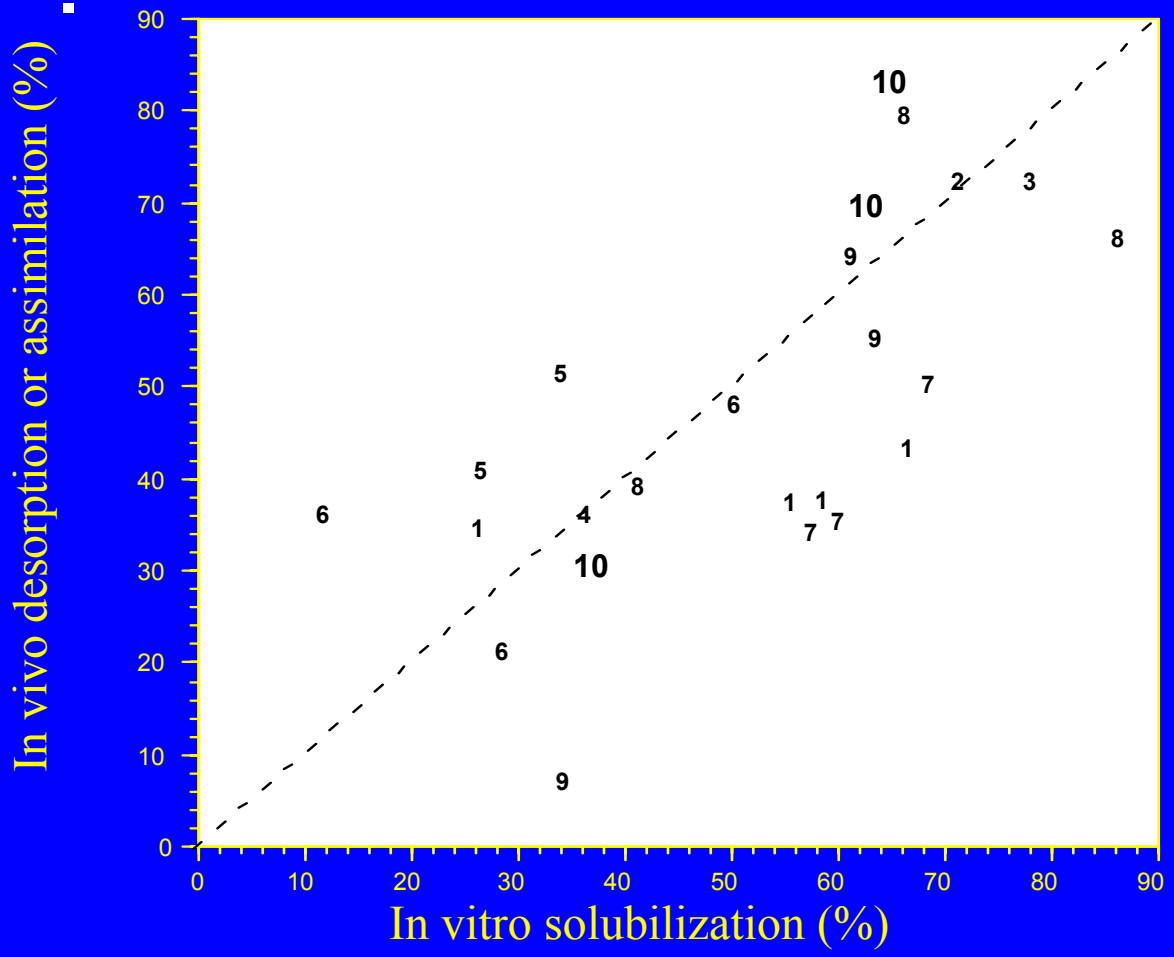
Approach to measure in vivo bioaccessibility





- 1 = A. brasilienis, Benzo(a)pyrene (Weston, unpub.)
- 2 = Nereis succinea, Hexachlorobiphenyl (Ahrens, et al., 2001)
- 3 = Nereis succinea, Tetrachlorobiphenyl (Ahrens, et al., 2001)
- 4 = Pectinaria gouldii, Hexachlorobenzene (Ahrens, et al., 2001)
- 5 = A. brasiliensis, Benzo(a)pyrene (Weston and Mayer, 1998)
- 6 = A. brasiliensis, Phenanthrene (Weston and Mayer, 1998)
- 7 = A. brasiliensis, Chlorpyrifos (Weston, unpub.)
- 8 = A. brasiliensis, Permethrin (Weston, unpub.)
- 9 = A. brasiliensis, DDT (Weston, unpub.)
- 10 = A. brasiliensis, Hexachlorobiphenyl (Weston, unpub.)

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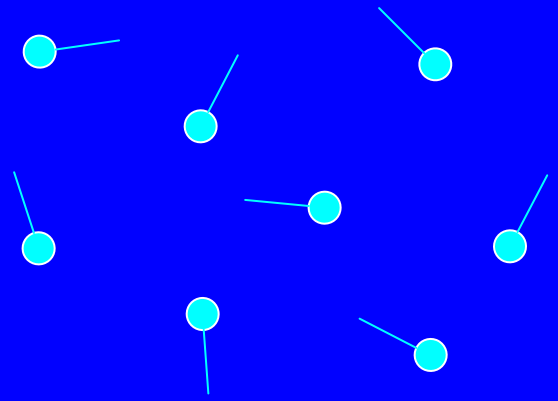
Basic properties of surfactants

Below Critical Micelle Conc.

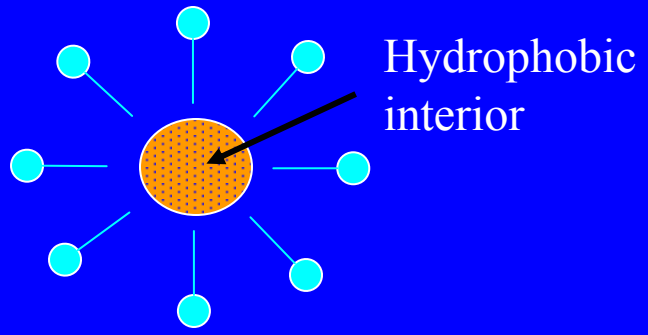
Surfactant molecules unorganized



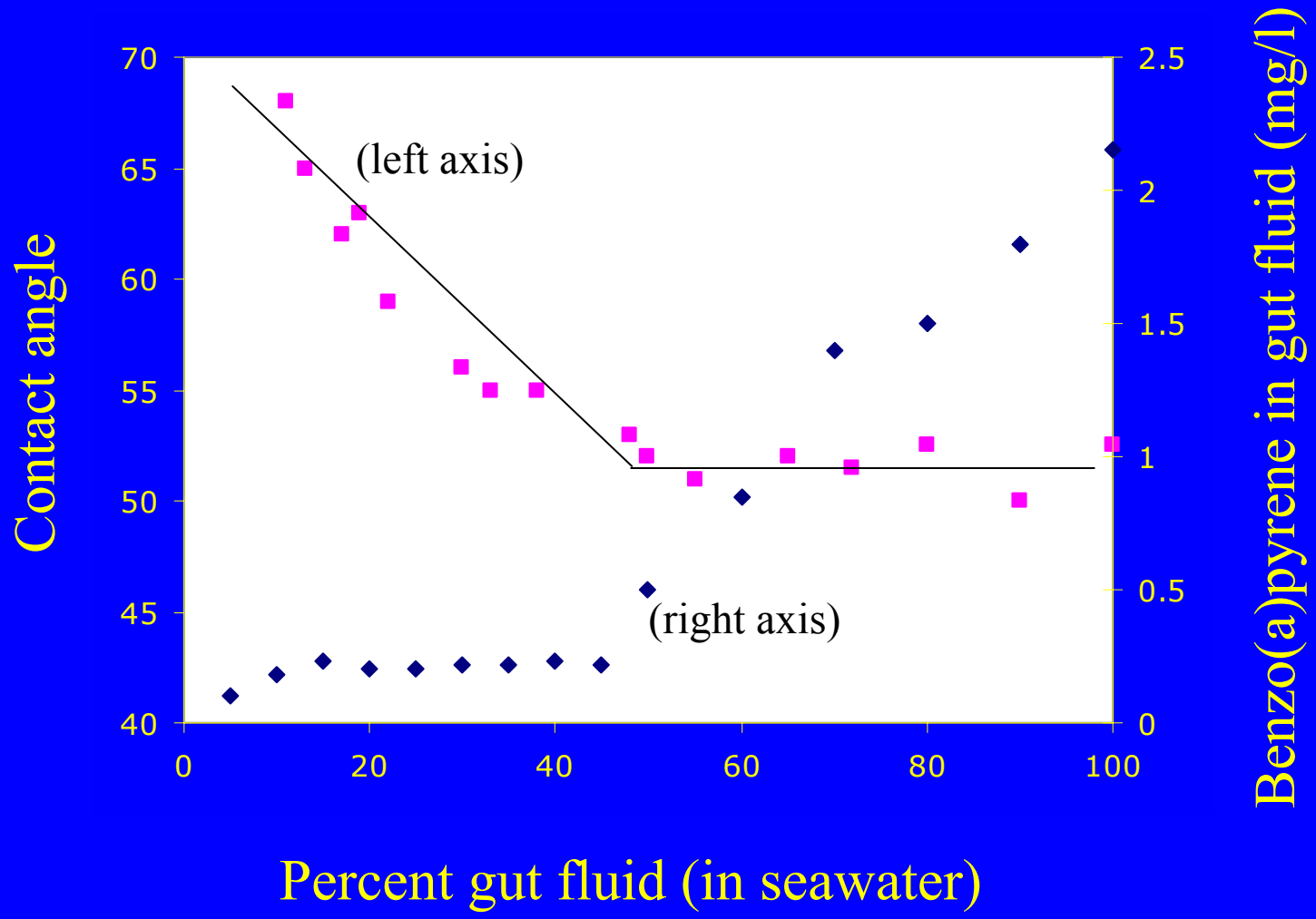
Surface tension inversely related to surfactant concentration

Above Critical Micelle Conc.

Surfactant molecules in micelles



Surface tension constant and independent of micelle conc.



Data from Voparil and Mayer (2000)

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Advantages of a synthetic gut fluid

- Greater availability to investigators without access to a suitable gut fluid "donor" species.
- Makes possible use of greater fluid quantities, lessening risk of ligand saturation during extraction.
- Avoids differences in gut fluid properties between individuals, times of collection, populations, etc.
- Low initial contaminant concentration.

Using a sodium taurocholate and bovine serum albumin gut fluid mimic…

- PAH solubilization potency of the artificial cocktail correlated with Arenicola gut fluid with an r-squared of 0.84.
- In tests with 12 PAH in 4 field-contaminated sediments, PAH solubilization by the cocktail was within a factor of 2 of Arenicola gut fluid in 40 of 48 PAH-sediment combinations.

Data from Voparil and Mayer (2004)

Summary

1. Digestive fluid extraction provides a biologically relevant and rapid assay of hydrophobic contaminant bioaccessibility.

2. The technique shows very good ability to predict in vivo bioaccessibility for deposit feeders. Predicting bioaccumulation is a taller order, and is probably especially difficult for metals.

3. A cocktail that is mechanistically similar to gut fluid shows promise and permits broad utilization of the technique to quantify bioaccessibility.